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THE MOSAIC DISEASE OF SWEET POTATOES

H. R Rosen.

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THE MOSAIC DISEASE OF SWEET POTATOES

H. R. ROSEN

One of the most important crops in Arkansas as well as in most of the Southern states is sweet potatoes. Therefore, any disease which is capable of injuring or lessening the value of this crop is of prime importance from the economic as well as from the scientific viewpoint. The sweet potato, *Ipomoea batatas* Lam., is a member of the Convolvulaceae, the morning glory family and is a native of tropical America where if undisturbed it blossoms and sets fruit. When such a plant is brought into a temperate region, with its much lower temperatures, it is readily understandable why its vitality is easily impaired and why it is so susceptible to disease. The stem-rot or wilt caused by *Fusarium* spp., black-rot caused by *Sphaeronema fimbriatum*, white-rust caused by *Albugo Ipomoeae-panduranae*, and scurf or soil stain caused by *Monilochaetes infuscans* are the more important field diseases which are commonly found in this state, while the soft or ring-rot caused by *Rhizopus nigricans*, black-rot also mentioned as a field disease, and charcoal-rot caused by *Sclerotium bataticola* are the common diseases developed in storage in this state.

All the diseases just mentioned are well known, and have been rather thoroughly investigated. Harter (4 and 5) gives good, popular summaries of them. The disease which the writer wishes to discuss here, sweet potato mosaic, is one which apparently has escaped attention up to the present* and has not been previously investigated. While the disease is to be found scattered more or less over the entire state of Arkansas, it is not abundant. The writer first detected it in 1918 in two fields near Pine Bluff, Jefferson County, Arkansas. Subsequently Dr. J. A. Elliott observed it in several fields located at Danville, Dardanelle and Belleville, Yell County, in two fields at Ozark, Franklin

* Mr. M. R. Ensign in a brief note (3) mentions this disease. His relationship to the discovery and identification of it may be gleaned from the following statement in a letter which the writer recently received from Mr. C. H. Thomas: "I recall that when we were examining some of these plants and you and Mr. Ensign were trying to decide upon it that you called our attention to the lighter mottling of the leaves and the peculiar notched edges of the leaves as being diagnostic symptoms of mosaic. Really, it did not occur to me that the discovery was of great import and naturally I did not anticipate that there would ever be any question as to its discovery, as I thought you and Mr. Ensign were in close cooperation in the work. I was decidedly surprised therefore when you told me of his article wherein he failed to mention your connection, as well as mine, in discovering the disease."

County and in one field near Fort Smith, Sebastian County. Mr. G. G. Becker, Chief Inspector of the Arkansas Plant Board in conversation with the writer stated that he had observed the disease in a large number of fields and that one to several diseased plants are likely to be met with in almost every sweet potato field. He definitely recalls having observed it at Rogers, Benton County, and at Van Buren, Crawford County. Mr. Becker has had exceptional opportunities of observing this disease, as well as other sweet potato diseases, while inspecting fields pursuant to the enforcement of the state law on sweet potato seed certification. However, while the disease is not abundant, where it is present it reduces the yield very materially. It is quite probable that the disease will be found in other states where sweet potatoes are grown.

In September 1918 the writer had occasion to visit some sweet potato fields near Pine Bluff, Arkansas in company with the county agents, Messrs. C. H. Thomas and J. Lambert, and with Mr. M. R. Ensign, then extension pathologist. Mr. Thomas had noticed some time before this a peculiar marking of the leaves of certain sweet potato plants of the Nancy Hall variety and had been unable to attribute it to any particular cause. The appearance of these plants in the field was very striking—they looked as if a large number of leaf miners had taken possession of certain individual plants marking almost all of the leaves upon them. Close examination revealed individual leaves with numerous fine whitish or chlorotic areas appearing as short or long, delicately penciled lines. These lines are very irregular, frequently joining each other at close intervals, and enclosing small healthy looking greenish areas, the whole producing a mottling or mosaic effect. Leaves with such mottling showed at times very uneven margins with deep lobes of varying shape and size and placed at irregular intervals. Plate 1 shows several of such leaves as they appeared in the field. The very fine penciling effect and the abnormal wrinkling or puckering of certain leaf areas surrounded by this penciling may be noted. Plate 2 fig. (b) shows a diseased leaf markedly wrinkled and furrowed in contrast to the normal leaf observed in fig. (e). Apparently the chlorotic portions of the leaf had failed to make the growth which the green portions had made and as a consequence these green portions held in by the surrounding chlorotic tissue took the form of pouches or uneven wrinkles.

The question naturally arises as to the advisability of using the name "mosaic" for this disease. According to Sorauer (9) p. 185, Adolph Mayer first used the name in 1885 in describing a highly infectious disease, tobacco mosaic. As will be discussed later the disease on sweet potatoes has not been found to be highly infectious, in fact, investigations so far have failed to show the

possession of any infectious properties. On this point, however, the writer feels that the methods used thus far to establish this feature may have been at fault and that by using other means the disease may yet be found to be infectious. Consciously or unconsciously the name "mosaic" has been used by pathologists in recent years not merely for diseases showing symptoms similar to the tobacco disease but in addition to this for those diseases whose etiology is as obscure as it is in tobacco mosaic. Thus numerous insect pests produce disturbances in plants which are quite similar to those found in mosaic diseased plants; the effect on plants of various leaf rollers, gall formers, etc., is well known, yet, such disturbances are not classed as mosaic diseases. Various other causes such as improper light, heat, moisture, or mineral food supply, as well as attacks by cryptogamic parasites may cause similar or comparable symptoms. Clinton (2) has given an excellent summary of various chlorotic disturbances under the name of "chlorosis." He classifies the different types of chlorosis according to their methods of perpetuation, as follows:-

I. Infectious chlorosis:
  A Communicable through the juice
  B Communicable through the tissues
    a By buds
    b By grafts
II. Non-infectious chlorosis:
  A Non-perpetuating
    a Affecting plants generally
    b Affecing isolated leaves or branches
  B Perpetuating
    a Through seeds
    b Through cuttings
    c Through buds or grafts

According to this classification the disease under discussion would be placed in accordance with our present knowledge, under non-infectious, perpetuating chlorosis in contrast to tobacco mosaic which would be placed under infectious chlorosis. However, the sweet potato disease has besides the leaf mottling so many characters in common with tobacco mosaic that the writer does not hesitate to classify it as a "mosaic" disease. These characters will be described later.

In passing it is worth mentioning various other chlorotic diseases which the writer has observed in this state. A peculiar variegated effect on cotton leaves has quite often been noted in which large leaf areas are creamy-white or greenish-white in color. Rubbing healthy leaves with macerated chlorotic material failed to produce infection either on the leaf to which the material had been applied or on the leaves above it which developed later in the season. *Passiflora lutea*, *Celtis* sp., and *Calycanthus floridus* have been found with variegated leaves. The mosaic diseases of *Phytolacca*, Irish potatoes, tomatoes and beans is quite common.

Very little tobacco is grown but the mosaic disease has been detected. Cucumber, spinach and sugar cane mosaics have not been observed. In addition Dr. J. A. Elliott has had under observation a peculiar mottling of various clovers including *Melilotus alba*, *Trifolium pratense* and *T. repens*.

In considering the question as to whether sweet potato mosaic is an infectious disease the following observations and experiments are presented. The disease as it appeared in the field was restricted to a few, more or less contiguous, plants. In some fields not more than one or two affected plants were to be observed, in others the disease would appear on about six to a dozen adjoining plants of the same row, suggesting the possibility that the slips were derived from the same mother plant or from the same root. In all cases normal, healthy plants were growing alongside of and intermingling with the diseased ones. Often aphids and other insects were observed on the diseased and on healthy plants. These observations suggested that the disease was hardly, if at all, infectious, although in the light of recent work on mosaic of Irish potatoes (6 and 7) one must bear in mind that it is possible to have infected plants without noticeable symptoms of disease, and that tubers of such plants when used for seed will produce plants which develop all the symptoms. To test the infectiousness of this disease about 30 trials were made both in the greenhouse and in the field. Freshly macerated, diseased material was rubbed on young and old, healthy leaves and on both the upper and lower surfaces of the leaves. In some of the tests the material was gently rubbed into the leaf so as to injure the hairs only, in others the leaf tissue was noticeably injured. Extracted juice from diseased material was injected by means of a hypodermic needle into veins, midribs, petioles and stems. The amount injected varied from a drop or two up to amout 0.2 cc. Thus far all such experiments have failed to produce visible infection. Not only the plants upon which the trials were made but also the cuttings grown from these plants have failed to show infection. Again, in the field and in the greenhouse healthy plants growing alongside of diseased ones showed no signs of infection in the presence of large numbers of aphids. Insect transmission was particularly subject to a severe test in the greenhouse where heavy infestation of aphids of two different species both on the diseased and on healthy plants growing alongside of each other, with runners from each overlapping, failed to show any transmission of disease from affected to healthy plants. Besides aphids, mealy bugs, white flies, and red spiders were also present in annoying abundance. However, the writer has not given up hope of producing infection and numerous other trials are under way. It is not impossible to conceive of a situation where a plant

may be infected without showing the disease and that proof of infection is not obtainable until the roots of such plants are used for seed purposes. As has been previously noted such a condition has already been discovered in Irish potato mosaic.

It has already been suggested how the disease may appear in any locality and how it may be propagated. In order to answer these questions more definitely the writer obtained some roots from plants which had shown the disease and imbedded them in sand on a greenhouse bench. Numerous shoots were obtained from these potatoes every one of which showed the typical disease symptoms as previously described. A large number of cuttings were made and set in the field. Plate 3 shows a row of plants grown from these cuttings alongside of a row of healthy plants. (Note the lack of foliage on the diseased plants) ; Plate 4 contrasts a single healthy plant with a diseased specimen. The difference is very marked—the diseased plants bearing comparatively few, undersized leaves and the healthy ones full of many dark-green leaves on good sized runners. Varying degrees of diseased condition may be noted in different plants. Some are so badly affected that they produce no runners, the leaves are extremely chlorotic and are often reduced to narrow, filiform and irregular shapes, others will produce fair sized runners with leaves that do not show extreme chlorotic conditions or markedly irregular shapes. Plate 2 fig. (a) shows some of these filiform leaves and figs. (c) and (d) show two leaves which do not possess extreme abnormality as compared to the lower normal one. At times only part of the leaf would show any chlorotic conditions as is indicated in the leaf shown in Plate 2, fig. (c), and again, no chlorotic effects may be observed, fig. (d). This last condition was only rarely obtained. In the extreme form of the disease not only would the entire mass of the leaf be greatly reduced but the vein mass including the petiole was likewise reduced. In such cases the lengths of the petioles were not noticeably different from the lengths of healthy ones but the circumferences had markedly lessened. The stems besides being stunted in length with noticeable reduction in size of internodes were also reduced in circumference. Often the margins of the leaf would curl upward (see Plate 4), and plants with such leaves would suggest in various aspects the disease known as curly-top of sugar beets. Taken as a whole the disease appeared in much greater severity on these plants than it did on the original diseased mother plants whose roots were utilized for propagation. Quanjer (6) p. 36, finds the same thing true for mosaic of Irish potatoes.

Judging from the effects of this disease on the stem and leaf system it is not difficult to imagine what happens to the development of the roots, especially fleshy roots which act as store houses of materials which have been elaborated in the leaves. It is no

wonder that growers report losses of 60 percent of their crop in diseased plants and indeed in our trials some plants were so badly diseased that hardly any marketable roots were obtained. Plate 5 shows such a plant with the root system intact. (Note that only one fleshy root is produced, which is considerably undersized. Also note a typical single leaf from this plant as compared to a normal leaf to the right of it.)

As to the cause of the disease there is no information to be offered except to say that no observable organism was obtained. It may be worth noting that there is a tendency at present to revive the "enzyme" theory in preference to the "parasite" theory, the latter having been favored the last few years under Allard's leadership. One of the contributing causes for this revival is due to the most recent work of Allard (1) in which he found that numerous chemicals, including the most effective germicides, even at comparatively strong concentrations had but little influence on the infectivity of the juice of mosaic-diseased tobacco plants. For example one gram of mercuric chloride added to 300 c. c. of the disease-producing solution had little influence on the infectivity of this juice, whereas one gram of mercuric chloride to 1000 cc. of water is universally used as a sterilizing agent. The highly resistant spores of tetanus bacillus are killed in three hours in 1:1000 mercuric chloride solution and spores of the anthrax bacillus are killed in two hours in the same strength of solution. Allard, however, has not indicated, so far as the writer knows, whether he accepts this as evidence against the parasitic theory. Certainly the evidence is not conclusive. In this connection it is interesting to note the suggestion made by Dr. E. F. Smith. In his study of abnormalities (8) produced by various chemical substances, such as ammonia, acetic acid, formic acid and aldehyd, all of which are products of the crown-gall organism, he draws the following conclusion: "I would suggest that the application of chemical substances in various dilutions to growing plants or plant organs, such substances in particular as are known or suspected to be produced by living organisms, or are present in soils as a result of decompositions, may prove to be a hopeful way of attacking certain unsolved and difficult problems in plant pathology, e. g., the aetiology of the mosaic diseases."

In conclusion a few words may be said concerning the control or eradication of the sweet potato mosaic. Observations thus far made indicate that the disease is not readily communicable, i. e., the disease is not readily transmitted from diseased to healthy plants. Even if it should be proved by later investigations that the disease is transmitted by insects and other means to healthy plants which produce diseased progeny the fact remains that it is by using affected roots that the disease is perpetuated. There is

no evidence to show that the disease is transmissable by means of infected soil. Any method of getting rid of diseased plants, especially the roots of such plants, should effectively control or entirely eradicate the disease. The following practice may be recommended: Destroy all diseased plants, including the roots, as soon as they appear in the field. It is best not to wait until digging time to do this for the reason that the tops of the plants may have withered by that time so that the diseased roots could not be distinguished from healthy ones. The best means to be used in destroying plants is to burn them. Two successive seasons of careful field observations and of roguing diseased plants will probably eliminate this disease from any one lot of potatoes. It is a good practice to raise one's own seed-slips so as to be sure that these are grown from healthy roots which came from disease-free plants.

LIST OF REFERENCES

(1) ALLARD, H. A. Effects of various salts, acids, germicides, etc., upon the infectivity of the virus causing the mosaic disease of tobacco. Jour. Agr. Research 13:619-637. 1918.

(2) CLINTON, G. P. Chlorosis of plants with special reference to calico of tobacco Report Conn. Agr. Exp. Sta. for 1914, pp. 357-424. Pl. 25-32. 1915.

(3) ENSIGN, M. R. Sweet potato mosaic. Phytopathology 9:180-181. 1919.

(4) HARTER, L. L. Sweet potato diseases. U. S. Dept. Agr., Farmers' Bulletin 714. 1916.

(5) HARTER, L. L. Sweet potato diseases. U. S. Dept. Agr. Farmers' Bulletin 1059. 1919.

(6) QUANJER, H. M. The mosaic disease of the Solanaceae, its relation to the phloem-necrosis, and its effect upon potato culture. Phytopathology 10:35-47. 1920.

(7) SCHULTZ, E. S., FOLSOM, DONALD, HILDERBRANDT, F. MERRILL and HAWKINS, LON A. Investigations on the mosaic disease of the Irish potato. Jour. Agr. Research 17:247-273. 1919.

(8) SMITH, ERWIN F. The relations of crown-gall to other overgrowths in plants. Memoirs Brooklyn Botanic Garden. 1:448-453. 1918.

(9) SORAUER, PAUL. Manual of Plant Diseases. Vol. 1. 1908. Translated by FRANCES DORRANCE. Part 8. 1917.

EXPLANATION OF PLATES.

Plate 1. Leaves showing the finely penciled or mottled appearance.

Plate 2. Fig. (a) Leaves showing extreme type of the mosaic disease, narrow, irregular, thread-like forms.

Fig. (b) Leaf showing a much wrinkled appearance.

Fig. (c) Leaf in which only half of the area shows the mottled condition.

Fig. (d) A mosaic-diseased leaf with no mottling but with an irregular margin.

Fig. (e) A healthy leaf.

Plate 3. A row of diseased plants to the left and healthy plants to the right. Note the bareness of the ground between diseased plants.

Plate 4. A single diseased plant above, in contrast to a healthy plant below, growing in the adjoining rows shown in Plate 3.

Plate 5. A diseased plant showing amount of root development—one undersized fleshy root. Note contrast between a leaf from this plant at the left and a normal leaf at the right.

PLATE I

PLATE II

PLATE III

PLATE IV

PLATE V